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Land Mollusc Middens

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Introduction

Archaeologists have long recognized middens of marine mollusc shells. As demonstrated in other chapters, marine shell middens are an important category of archaeological site, from which we can learn much about hunter-gatherer subsistence strategies and settlement patterns; however, they are not the only places where large accumulations of molluscs are found. A second, less widely recognised, class of shell midden, similar in size and formation to marine shell middens, is composed of terrestrial mollusc species and frequently found inland rather than in coastal locations. These land snail middens are often referred to as 'escargotières', from the French term denoting a place where snails are raised. They are also less frequently called 'rammadiya' (Lubell, 2001) and 'cendrières' (Gobert, 1937; Morel, 1974), both of which refer to the considerable amounts of ash often associated with snail middens. They are composed of large volumes of land snails, often of one, or a narrow range of, species, within an ashy matrix which also contains mammal bones, charcoal, plant macrofossils and lithics. A good example is Pond's description of the Capsian escargotières in Algeria as "a group of refuse heaps welded into a single mound…composed of snail shells, camp fire ashes, hearth stones, animal bones and tools of bone and flint" (Pond 1938,109).

In research terms the land mollusc middens present questions similar to those of the coastal marine mollusc middens, such as those along the Atlantic seaboard of Europe (Milner *et al*. 2007), particularly Denmark (Andersen 2000), and in many other parts of the world (Bailey *et al* 2013). In both cases the quantities of shells are enormous but their significance in the diet must be evaluated alongside other, less obvious, animal and plant resources, requiring detailed laboratory analysis. There is also the question of whether such a concentration of food debris is itself indicative of sedentary communities. In the case of some examples of both Atlantic marine mollusc middens and Mediterranean land mollusc middens, theories of sedentism have been strengthened by the occurrence of burials associated with the middens. The assumption is that burial is more likely to occur when settled populations identify with a specific place. This issue is illustrated by the Taforalt case study below.

Distribution of land snail middens

Land snail middens are a widespread phenomenon occurring throughout Southern Europe, the Near East and North Africa (Figure 1), yet few have been excavated and recorded in detail (Lubell 2004b; Rabett *et al* 2010). Fortunately the evidence from several sites has recently been reviewed in a special volume of *Quaternary International* (Lubell and Barton 2011). Some of the most well-known land snail middens are located in North Africa, particularly in the Maghreb (Morocco, Tunisia and Algeria) and in Cyrenaica in Libya. The archaeology of these middens is mainly attributable to two cultural groups; the Iberomaurusian and the Capsian. Those belonging to the former are found in caves and rockshelters, often near the coast, and date to between 17,000 and 11,000BP (Lubell, 1984; 2001). Those belonging to the Capsian tend to be open-air sites which occur further inland, mainly in Algeria and Tunisia, and are Holocene, dating between 11,000 and 6,000 cal BP (Lubell, 2001). Key sites in North Africa include: Taforalt, also known as Grotte des Pigeons (Taylor *et al*, 2011; Taylor, 2014), Ifri n'Ammar (Moser, 2003; Hutterer *et al*, 2014), Ifri Oudadane (Morales *et al*, 2013) and Taghit Haddouch (Hutterer *et al*, 2014) in Morocco; Tamar Hat (Saxon, 1974) and Aïn Mistehiya (Lubell *et al*, 1975; Lubell *et al*, 1976) in Algeria; and Haua Fteah in Libya (McBurney, 1967; Hill *et al* 2015).

After North Africa, the French Pyrenees has one of the highest concentrations of land snail middens. Important sites in the region include Grotte de Poeymaü and Mas d'Azil (Bahn, 1983a and b). Land snail middens can also be found in other European countries such as Croatia, where Pupicina Cave has been investigated (Miracle, 1995; 2001); Italy (Lubell *et al*, 1995; Bonizzoni et al, 2009; Lubell, 2004a); Portugal (Lubell, 2004a) and Spain. Some of the most well-known shell middens in Spain are the Asturian middens along the Cantabrian coast (Aparicio *et al*, 2001; Lubell, 2004a). Although known for their marine shell component, many also contain large numbers of land snail shells, as recorded at La Fragua cave (Gutierrez-Zugasti, 2011). Land snail middens can also be found outside of this region, such as at Nerja Cave in Andalucía (Auro-Tortosa *et al*, 2002) and a chain of sites close to the east coast of Spain (Lloveras et al 2011; Fernéndez-López de Pablo et al 2011).

Smaller accumulations of land snails are also regularly found at archaeological sites in the Zagros Mountains (Eastern Iraq and Western Iran), with ongoing work in the region by the Central Zagros Archaeological Project continuing to produce evidence of small accumulations of *Helix salamonica* at Neolithic sites including Bestansur, Sheikh-e Abad and Jani (Shillito, 2013; Iversen, 2015). Recent work by Rabett *et al* (2010) has highlighted the presence of a land snail-dominated midden in Hang Boi Cave (Fortune Teller's Cave) in Trang An Park in Vietnam. Exploitation of the Giant Land Snail (family Achatinidue) is also reported in the Middle Stone Age Bushman Rock Shelter in South Africa, where some were heat affected (Badenhorst and Plug, 2012), and there is also possible evidence for their consumption in Later Stone Age contexts in Kuumbi Cave, Zanzibar (Skipton *et al* 2016). These sites push the known distribution of sites well beyond the circum-Mediterranean. It seems likely that the distribution of evidence for land mollusc consumption will continue to expand as archaeologists become more aware of their potential contributions to the diet.

In contexts where there are accumulations of shells without substantial middens, consideration must be given to whether the accumulation results from human activity, or could be a natural death assemblage (Girod 2011). The latter will generally be characterized by a range of growth stages and species, many not edible, and the absence of associated anthropogenic artefacts. Assemblages derived from human consumption are generally fully grown and of one, or a narrow range of, edible species, occur in specific contexts with cultural material, and show evidence of repetitive midden-forming behaviour; shells are also often heat-affected.

The earliest clearly defined land snail middens are Upper Palaeolithic in date, the best examples of which are those associated with the Late Stone Age Iberomaurusian culture in North Africa such as Taforalt, Ifri n'Ammar and Tamar Hat. The earliest substantial mollusc midden layers are c. 18,800 cal BP (Unit IV) at Tamar Hat (Saxon 1974,50; Hogue and Barton 2016). There is a notable increase in the number and distribution of land snail middens in the early Holocene, with the majority of sites being Mesolithic in date, such as the Azilian middens in Northern Spain and the Pyrenees. Le Fragua cave in Spanish Cantabria contains a substantial midden estimated at 15,000 land snail shells, beginning *c* 10,900 cal BP (Gutierrez Zugasti 2011). The Capsian middens in North Africa also date to the early Holocene; however, many continue into the Neolithic period with land snail consumption continuing alongside early domestication at sites such as Ifri Oudadane (Lubell *et al* 1976). A similar pattern is seen in the Zagros Mountains where land snails are again found in contexts containing early evidence for animal domestication (Shillito, 2013; Iversen, 2015). There is also evidence for land snail consumption into the Neolithic, Roman and Hellenic periods in Libya indicating that "eating of gastropods seems to have been a consistent feature of the coastal Cyrenaican sites through the Holocene" (Hunt *et al*, 2011,24).

Consumption of a wide range of land mollusc species continues to this day in Mediterranean countries and beyond. *Helix pomatia* eaten as escargot is particularly well known and *Cornu aspersum* (formerly *Helix aspersa*) is similarly consumed. The first is thought to have been introduced to Britain by the Romans for food (Davies, 2010) but there is no obvious reason why that did not also apply to the second which has been considered an accidental Roman introduction. In Portugal *Theba pisana* is a traditional dish with some 4000 tonnes being consumed annually.

Of particular interest is that present day land snail consumption in parts of the Mediterranean seems to be associated with special festivals and gatherings at certain times of year. Examples are snail festivals at Caragol, Spain in May, Graffignano, Italy in August and Digoin, France in August, at all of which vast quantities of snails are consumed (Taylor 2014). Ethnohistoric practices associated with recent snail gathering have been particularly well documented in Crete where consumption is particularly associated with festivals before Easter and in mid August (N. Galanidou pers. comm.). The Cretan festivals occur at times where snails were particularly abundant and easily gathered. Such events serve to remind us that land molluscs may be seen not just as an everyday item of diet, or something to be eaten when other resources were scarce; indeed the ethnohistoric evidence often identifies them as a delicacy, and a food of particular social significance because of an association, however created, with special events. Miracle (1995) has interpreted the molluscan evidence from Pupicina cave in terms of feasting associated with burial practice.

Methods of land mollusc midden investigation

Investigation of land mollusc middens requires a strategy carefully constructed to facilitate investigation of the key research questions. The approach is designed to obtain, not just molluscs, but other evidence, including plant and animal, which will contribute to an understanding of the diet, environment and way of life of the people concerned. Some previous investigations have been restricted to the small numbers of larger intact shells (Gutierrez-Zugasti, 2011; Lloveras *et al*, 2011; Lubell *et al*, 1976), or have used large mesh sieves for collection. Such an approach introduces a bias towards larger and more robust species. This is particularly problematic since many land mollusc species are fragile, easily crushed in an active occupation area, and tend to be represented by apices and fragments. Hand collection and larger sieve meshes prevent quantification and also mean the loss of small land mollusc species. Those include species too small for consumption but potentially of palaeoenvironmental significance; these can be well represented in shell middens both land and marine (Nielsen, 2007). The approach recommended, and used in the Taforalt case study outlined below, is an adaptation of the methodology well established in the environmental analysis of land molluscs (Evans 1972; Davies 2008). Samples are taken in a column of specific dimensions (eg 0.25 X 0.25 m) and at suitable intervals (eg 50-200 mm), respecting stratigraphic boundaries, through the thickness of the midden. This facilitates investigation of change through time and quantification of the numbers of shells per unit volume as a proportion of the volume of stratigraphic horizon, or the total midden. In this way the food resource represented by the midden can be quantified and potentially some estimate of its calorific value obtained.

The individual samples are weighed, soaked in water and floating material is washed onto a sieve; 0.5 mm mesh is adequate to retrieve tiny and fragmentary shells (Fernández-López de Pablo *et al*, 2011; Hunt *et al*, 2011; Rabett *et al*, 2010; Taylor *et al*, 2011), but a finer mesh may be desirable where tiny seeds are also present. Where sieving down to 1mm or 0.5mm has been done on land snail midden sites this has facilitated recovery of both large, edible species and smaller species naturally present. Material that does not float is washed onto a nest of sieves eg 4 mm, 2 mm, 1 mm and 0.5 mm and cleaned with a jet of water. Division into size fractions makes sorting easier. The sieves are dried and the material sorted under a binocular microscope, not only for the molluscs but also the other plant and animal resources which may contribute to an understanding of the diet and environment of the site in question.

Archaeological investigation of land Mollusca is relatively straightforward in Britain with a relatively small and well-studied fauna, reasonable knowledge of associated habitat and present-day distributions, good published guides and reference collections (eg Evans 1972; Kerney and Cameron, 1979). A substantial advance has been made with the recent publication of a comprehensive, well illustrated guide to the Mollusca of the whole of Europe (Welter-Schultes 2012). Even so, the extent of molluscan knowledge varies nationally within Europe and is in general greater for northern than southern Europe. Of the Mediterranean countries where land mollusc middens are found, detailed distributional data is available for Portugal, the Balearics, Malta, Albania, Serbia and Crete and some Aegean islands (Welter-Schultes 2012, 7). Beyond Europe in North Africa and the Near East the faunas, and particularly knowledge of their ecological preferences and distributional ranges, are in general very limited compared to Europe, although some areas are better served than others, for instance Israel (Heller 2009) and Turkey (Schutt 2005). In parts of North Africa and the Near East much of the taxonomic work was done during the period of colonial European rule in the nineteenth and early twentieth century and the coverage is patchy, species description are sometimes limited and there has been a tendency to splitting, with the result that what may be the same species can have multiple names. Working in areas where the mollusc fauna is less well known it is likely to be necessary to carry out work on the present day fauna in order to obtain information on species ecological preferences; we have also found this very helpful in identifying landscape contexts which are particularly suitable for the collection of large numbers of land molluscs. Work in areas where the molluscan fauna is less well known also requires the detailed description and illustration of the species named to facilitate comparison with those found elsewhere and to contribute eventually to an improved taxonomy.

Quantification of mollusc shells is generally based on the minimum number of individuals derived from the counts of apices. The results may then be presented as a histogram of species abundance through the midden, similar to the diagrams used for environmental land snail analysis (Evans 1972). If resources allow it is desirable to obtain sequences of samples from more than one part of a midden in order to investigate lateral variation, which, depending on how it grew, may also equate to a temporal sequence. Where many of the shells are intact, morphometric studies of whole shells can be employed (Claasen 1998), to investigate, for instance, changes in size over time which might indicate decreasing shell size as a result of population over-exploitation (Mannino and Thomas, 2001; 2002) or environmental changes.

Unfortunately in many land snail middens the shells are highly fragmented, limiting a morphometric approach.

Taforalt land snail midden as a case study

Taforalt is a large cave site located in the Beni Snassen mountains in northeastern Morocco, close to the Algerian border, 40km from the Mediterranean Sea. It is well known for its large Iberomaurusian cemetery at the back of the cave (Ferembach 1962; Humphrey *et al* 2012). The site also contains thick anthropogenic deposits which were the subject of large scale excavations in the 1950's (Roche, 1963) and more recently between 2003 and 2016 by a joint Moroccan and British team led by Professors Abdeljalil Bouzouggar (Rabat) and Nick Barton (Oxford). The sequence has a high precision chronology modelled from a sequence of 52 AMS radiocarbon dates (Barton *et al* 2013). The Iberomaurusian occurs in two distinct units, the upper part of the Yellow Series and the Grey Series (Figure 2). The lower of the two units, the Yellow Series, appears to be sediment washed into the cave; this contains lithic artefacts, bones and some shells. The Grey Series deposits formed between 15,000 and 12,600 cal BP, after which the sequence is truncated, so there are no Holocene sediments. The Grey Series is a very different, essentially anthropogenic deposit, containing far more abundant evidence of human activity such as lithics, artefacts and chips, animal bones, charcoal, land snail shells and stones, some heat-affected (Figure 3). The Grey Series layers at Taforalt have always been described as a 'land snail midden'. The starting point at Taforalt was therefore to test this hypothesis through detailed scientific analysis. All too often, particularly in Mediterranean contexts, the anthropogenic nature of such deposits has been assumed rather than evaluated.

Analysis of bulk samples taken from a 0.25 m wide column in Sector 8 was undertaken in order to investigate this hypothesis and address wider questions such as methods of collection and consumption, contribution to diet and environmental change (Taylor and Bell forthcoming). The Yellow Series deposits below have been analysed from about 19,500 cal BP (Figure 5). In the Yellow Series, species which are likely to have been eaten account for only 17% of the total molluscs; these are species also present in the overlying midden suggesting small-scale molluscan consumption from 19,500 cal BP. Indeed individual large shells of *Otala punctata* were observed in the Taforalt Calcareous Group sediments Layer R26 dated *c.* 90-95,000BP, although here there were no concentrations of shells and only scattered worked lithics and charcoal (S. Collcutt pers. comm.). More significant were concentrations of land molluscs in ashy hearth deposits in the Lower Laminated Group Layer R22 which is dated *c*. 80-82,000BP (Clark-Balzan 2012; Barton *et al* 2014). This layer also contained perforated shell beads of the marine mollusc *Nassarius gibbosulus* which is regarded as among the earliest evidence of human symbolic behaviour worldwide (Bouzouggar *et al* 2077; De Errico *et al* 2009).

The overlying Grey Series midden, is up to 4 m thick, and, judging by the exposed section, may originally have comprised *c*. 1500 m^3 of largely anthropogenic sediment. Rough calculations based on the number of shells in the sampled column indicate that it may originally have contained something like 62 million shells deposited over about 2400 years, ie maybe 28,000 per year. Inaccurate as these numbers probably are, they give some indication of the significance of molluscan exploitation.

Analysis of the molluscan component identified four main species within the Grey Series deposits at Taforalt: *Dupotetia dupotetiana*, *Otala punctata*, *Alabastrina soluta* and *Cernuella globuloidea* (Figure 4). *Helix aspersa* (*Cornu aspersum*) was also present in smaller numbers. All five species are of a size suitable for consumption and together account for over 99% of the total molluscs recovered from the Grey Series. A clear bias can therefore be seen towards large, edible species in the Grey Series. Lithic artefacts, abundant lithic debitage, animal bone, charcoal and charred plant remains were also recovered from the mollusc samples which supports the hypothesis that the majority of land snails in the Grey Series are anthropogenic in origin. *Dupotetia dupotetiana* is by far the most commonly occurring species, accounting for over 60% of all the molluscan material in the Grey Series and over half of all apices overall. In comparison, *Otala punctata* and *Alabastrina soluta* occur in much lower numbers throughout the sequence. *Cernuella globuloidea* is also much less frequent, accounting for only 9% of the total edible molluscs, the majority of which come from the lower half of the Grey Series. At around 14,000 Cal BP there is a steep decline in this particular species which may be the result of environmental changes. At the same time there is an overall increase in mollusc numbers representing a further intensification in the use of molluscan resources. Thus it appears that the use of molluscan resources began in a small way by about 80,000BP, they became more consistently used after the last glacial maximum, represented in North Africa by a cooler dry period with much dust input, and saw major intensification with the onset of midden formation *c.* 15,000 cal BP and further intensification from 14,000 cal BP.

The intensification represented by the Grey Series midden from 15,000 cal BP sees a remarkable diversity of dietary resources, this includes extensive evidence for the use of plant resources studied by Dr J. Morales, especially sweet acorns and pine nuts. High levels of caries in the human burials are also interpreted as indicating a diet with high levels of consumption of starchy plant foods (Humphrey *et al* 2014). Animal bone is also frequent in the Grey Series and a marked increase in sedimentation rate is to a large extent of anthropogenic origin. This intensification is a particularly noteworthy manifestation of the Broad Spectrum Revolution which Flannery (1969) identified in the Middle East in the late glacial and initial Holocene but has since been identified at similar dates in many parts of the world. At Taforalt the onset of the Grey Series midden was followed soon after by development of an extensive cemetery at the back of the cave. Evidence of middening, Broad Spectrum resource utilisation and particularly burial have often been taken as indicating increased sedentism. The plants utilised indicate activity from late spring to autumn and the nuts could have been stored and used over winter (Humphrey *et al* 2014). The hypothesis of sedentism can only be fully addressed when the whole range of dietary resources and human skeletal evidence from the site has been put together in the monograph currently in preparation (Barton *et al* forthcoming). The same applies to evaluation of the relationships between the molluscan and other environmental and palaeoeconomic evidence and wider evidence for environmental changes. It is notable, however, that the major sedimentary transition marked by the onset of the Grey Series midden coincides with the generally warmer Greenland Interstadial 1 (Grootes *et al*, 1993). A marked decline of *Cernuella globuloidaea* occurs at the time of a short-lived cooler episode Greenland Interstadial 1-1d. The period of most intensive mollusc exploitation occurred following this in the later, and generally cooler, part of the Greenland Interstadial. There is no indication from the Mollusca of a subsequent change which might correspond to the climatic downturn of Greenland Stadial 1 and indeed the dating sequence indicates that the cave deposits have been truncated to below this level at the point sampled, also resulting in the loss of all Holocene stratigraphy. However, wood charcoals from the top of the sequence, nearer the cave entrance, do indicate the onset of a significant cool damp period with dates within Greenland Stadial 1 (S. Collcutt pers. com.)

Climate and seasonality

A number of studies have suggested that the periodicity of mollusc collection coincided with periods when the molluscs today are observed to be particularly active. For instance in the case of Holocene Iberian example at Balma del Gai, Spain (Lloveras *et al* 2011) collection in late summer and autumn was suggested and at Arenal de la Virgen and Casa Corona activity in spring and summer was proposed (Fernández-López de Pablo 2011). At La Frangua the most suitable period for collection was suggested as summer and autumn, although vertebrate faunal evidence indicated that the main period of activity was in winter (Gutiérrez Zugasti 2011). The clustering behaviour of molluscs in spring on woody plants noted in lowlands downriver of Taforalt showed how significant numbers of molluscs could have been collected. However, we must exercise caution in extrapolating from modern analogues to the conditions of the early Holocene and especially the late Pleistocene.

The analysis of stable isotopes from shells provides new ways of addressing issues of past climate and seasonality (Thomas 2015 a and b). Oxygen isotope analysis of sequences of land mollusc shells can provide palaeoclimatic sequences (Leng and Lewis 2014). Analyses of isotopic values of modern land snail shell have been used to demonstrate the relationship between mollusc shell isotope signatures and environmental factors (Yanes *et al*, 2009; Stott, 2002; Zanchetta *et al*, 2005). These data can then be used to provide a baseline from which to compare archaeological samples (Lécolle, 1985; Balakrishnan *et al*, 2005; Colonese *et al*, 2010; Kehrwald *et al*, 2010; Stevens *et al*, 2012; Yanes *et al*, 2011). This contributes to a multi proxy approach to reconstruction of past environments and palaeoclimate. For further discussion of methodologies and interpretation of data see Prendergast *et al* (2015). Carbon and oxygen isotope analysis of incremental bands in the shells of the African land snail *Limicolaria kambeul chudeaui* from Ethiopia have provided evidence of climatic seasonality (Leng *et al* 1998). Land mollusc shells, at least of some taxa, show evidence of periodic banding both on a coarse scale on the surface of the shell and on a very fine microscopic scale in thin section, particularly in the thickened apertures of some species, eg *Dupotetia dupotetiana* at Taforalt (F. Katsi pers comm). Periodic banding coupled with isotopic analysis could potentially establish the seasonality of land mollusc collection and, when combined with other sources, test hypotheses of sedentism or mobility.

Shell collection and consumption

One question which arises on sites with enormous collections of land mollusc shells is how prehistoric communities gathered such numbers. Confronted with this, some writers have even flirted with the notion that the molluscs were farmed (Bahn, 1983 a and b; Fernández-Armesto, 2001), although no convincing evidence has ever been advanced in support of this idea. It may be more realistic to think in terms of non-analogue ecological communities in the rapidly-changing climatic conditions of the late glacial and early Holocene, creating particularly favourable conditions for molluscan life round parts of the Mediterranean. Nor can we exclude the possibility that people contributed in some ways to the creation of niches in which these Mollusca flourished, just as the Mollusca and other resources contributed to the creation of niches with a broad spectrum of resources in which some groups became more sedentary.

Some indication of how large numbers of shells might be collected are provided by a small scale survey of the present day malacofauna around Taforalt. Close to the cave *Alabastrina soluta* was to be found in micro-caves in the limestone, apparently the result of solution-etching of the rock by generations of molluscs themselves, as recorded elsewhere in the Mediterranean and on Mendip, UK (Danin 1986; Stanton 1986). Survey in the wider Moulouya Valley between Taforalt and the coast recorded large numbers of *Dupotetia* aestivating on bushes, often in tight clusters, as shown in Figure 5. At one location *c.* 100 *Dupotetia dupotetiana* individuals were counted on a single bush. This bush was one of at least 10 within a 10 m radius indicating that somewhere in the region of 1,000 molluscs could be collected from that small area with minimal effort.

Consumption of land snails may be relatively easy to recognise where there are large numbers associated with anthropogenic material in middens. More challenging is the interpretation of small collections on sites where they might be assumed to be of natural occurrence. This is perhaps the case with *Helix pomatia* and *Helix aspersa (Cornu aspersum),* both introduced to Britain by the Romans (Davies 2010). In Spain there are records of very substantial middens of *Cepaea nemoralis* at Fragua Cave in Cantabria (Gutierrez Zugasti 2011) and Balma del Gai (Lloveras *et al* 2011). *Cepaea* has a wide European distribution and this poses the question of whether it has been overlooked as a potential resource in Britain where, in the first half of the Holocene, it is the only land mollusc of sufficient size for consumption.

Various writers have discussed the ways in which molluscs were prepared for consumption. Hutterer *et al* (2011; 2014) found small intentional perforation marks on a large percentage of shells in the midden at Taghit Haddouch in North East Morocco, which he concluded were to break the vacuum so that the snail could be sucked from the shell; these perforations are not recorded before the Neolithic. It has often been suggested that cooking was involved (Lubell *et al* 1975; Bar, 1977; Bahn, 1983; Heller, 2009). That possibility is strengthened by the abundance of charred plant material and heat-fractured rocks in several sites, especially Taforalt where up to 60% of Grey Series shells were heat-affected. Today the most commonly employed method for cooking snails is immersing them in boiling water (Arrébola Burgos *et al*, 2001) which loosens the muscles and enables the flesh to be easily removed from the shell, a method which Lubell *et al* (1975) believe was used by prehistoric North African communities. They may have used skins, or potentially ceramic vessels at Capsian sites such as Aïn Mistehiya, as containers within which water could be boiled using heated rocks known as ‘pot boilers’. Another possibility is that snails were cooked directly by placing them in the fire bed or onto stones heated in the fire (Bonizonni *et al*, 2009; Heller, 2009; Matteson, 1959; Heller, 2009; Pond, 1938), or into large pits lined with heated rocks, a technique for cooking a range of foods which is widely attested through ethnographic studies (Linderman, 1962; Wandsnider, 1997; Meehan 1982). Experiments in cookery of *Helix aspersa maxima* at Reading University showed that they can be very rapidly cooked in boiling water by adding hot rocks to a container, although those roasted on hot rocks were, to modern taste at least, more palatable (Figure 6).

Conclusion

Land Mollusc middens have, until recently, seldom received the attention from archaeologists given to middens of marine Mollusca. Land and marine middens are both significant environments of deposition preserving a wide range of palaeoenvironmental evidence. When the Mollusca themselves are analysed in detail, as at Taforalt, alongside the other sources of biological evidence using a comparative multi-proxy approach, they can make a significant contribution to study of palaeoeconomy, palaeoenvironment, sedentism, mobility, and past diet.

Land mollusc exploitation is attested at Taforalt from *c.* 80,000 BP but that was small scale and episodic. Major intensification in the use of Mollusca took place c. 15,000 cal BP during the latter half of the Late Glacial Interstadial. The midden which formed from 15,000-12,600 cal BP contains a remarkable diversity of food resources and is a classic case of Broad Spectrum resource utilisation in the Late Glacial Interstadial. The Palaeolithic land mollusc middens occur particularly in North Africa with scattered occurrences north of the Mediterranean where most of the middens are Holocene (Figure 1). They are mainly of Mesolithic date but there are examples up to Roman and Medieval times and land molluscs are still consumed in large numbers particularly in some religious festivals.

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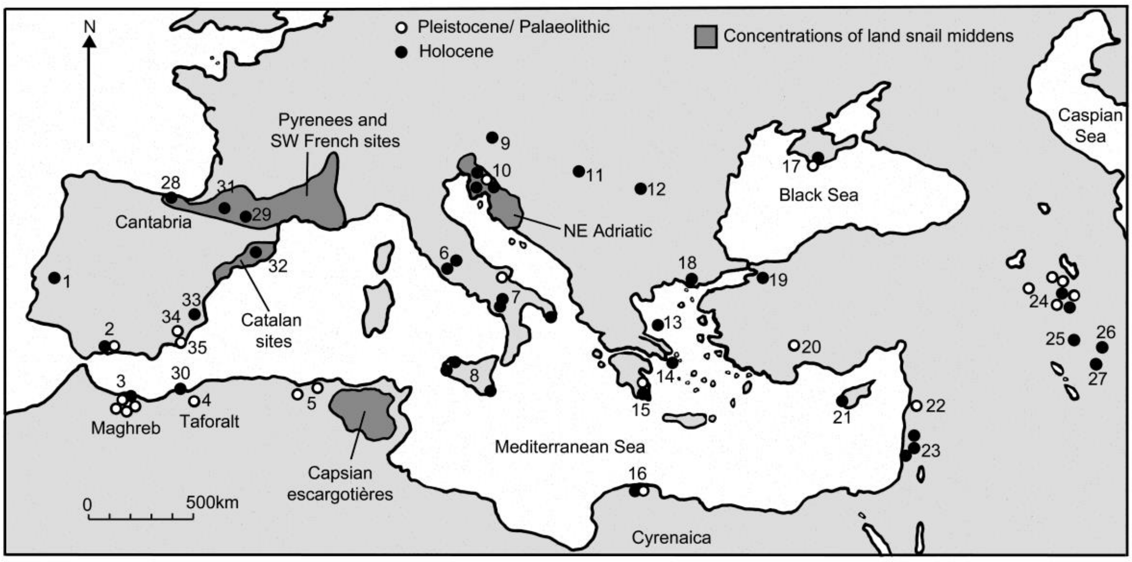

1. The Muge middens
2. Nerja Cave
3. Ifri n'Ammar, Ifri-el-Baroud, Taghit Haddouch, Hassi Ouenzga
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5. Afalou bou Rhumel, Tamar Hat
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14. Maroulas
15. Franchthi Cave
16. Haua Fteah
17. Lapsi VII
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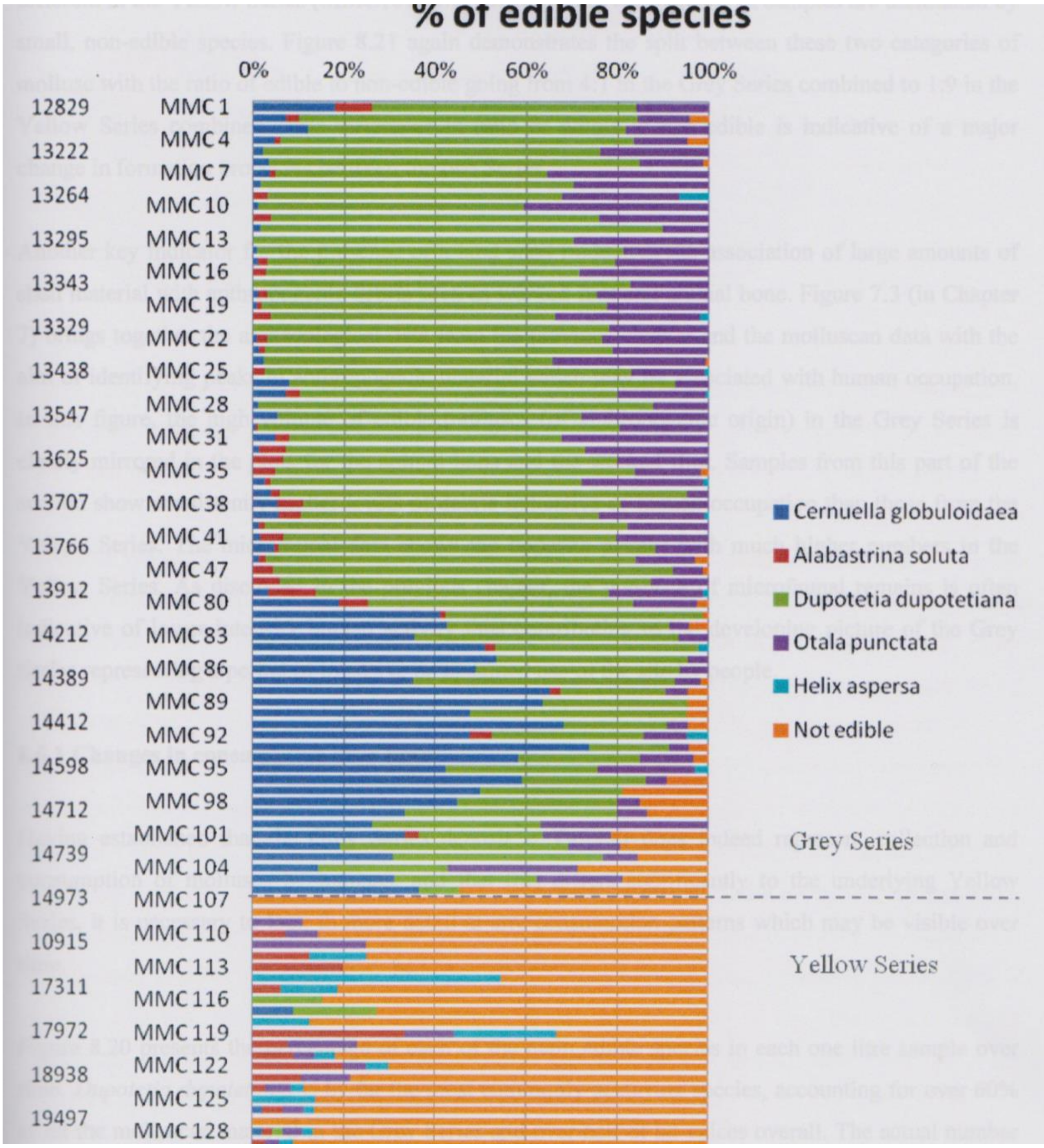
19. Illipinar
20. Öküzini Cave
21. Kissonegra Mylouthkia
22. Ksar'Akil
23. Djebel Kafzeh, Hoyonim Cave, Erq el-Ahmar, Mugharet ez- Zuitina, Ein Gev
24. Asiab, Gerd Banahilk, Jarmo, Karim Shahir, Nemrik 9, Tepe Sarab, Shanidar Cave Layer B, Warwasi, Zawi Chemi Shanidar
25. Bestansur
26. Sheikh-e Abad
27. Jani
28. La Fragua
29. Mas d'Azil
30. Ifri Oudadane
31. Grotte de Poeymau
32. Balma del Gai
33. Arenal de la Virgen and Casa Corona
34. Algarrobo
35. Caballo

Figure 2. Taforalt: the section of the Grey Series Iberomaurusian midden and the underlying yellow series sediments.

Figure 3 Mollusca and a range of other biological evidence from the Taforalt midden on the sieve (scale 5cm).

Figure 4. Taforalt midden mollusc diagram showing % of edible and non-edible species, on the left are dates cal BP based on the model in Barton *et al* (2013).



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a b

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